Amendments to the Specification:

Please replace the paragraph beginning on page 1, line 9, with the following rewritten paragraph:

Cellular telephone systems are operated in environments that give rise to multi-path or reflections of ~~the~~ their signals, particularly in urban environments. In FIG. 1, base station transmitter 1 broadcasts its signal to remote station 2 (often mobile) along direct path 3. However, owing to the presence of tall building 4, transmitter 1 also broadcasts its signal to remote station 2 along indirect path 5, thus, giving rise to angular spread AS between the direction of arrival of direct path 3 at remote station 2 and the direction of arrival of indirect path 5 at remote station 2. Direct path 3 and indirect path 5 are recombined at remote station 2 where constructive and destructive superimposed signals cause random or what appears to be random fading and black out zones.

Please replace the paragraph beginning at page 4, line 28, with the following rewritten paragraph:

These and other objects are achieved with an alternative embodiment where the method includes selecting at least two beams of plural beams formed by a multi-beam antenna array associated with a first station for transmission of ~~a corresponding~~ at least two space-time coded signals produced by a space-time encoder, determining a time delay associated with each of the at least two space-time coded signals as received in each respective beam, and setting into a variable delay line the time delay corresponding to each beam, each variable delay line being coupled between the multi-beam antenna array and the space-time encoder.

Please replace the paragraph beginning at page 6, line 28, with the following rewritten paragraph:

To achieve greater spectral efficiency of transmissions from the base station while minimizing co-channel interference, independent power management of individual beams transmitted by different antennas of the diversity antennas has been developed, and beamspace time encoder techniques ~~has~~ have been developed to exploit angle of arrival diversity and exploit spatial power management of independently directed beams. Beamspace time techniques differ

from known space time encoder techniques by its use of two or more independently directed orthogonal beams to exploit power and beam width management and angle of arrival diversity. Orthogonal beams are separately identifiable to the receiver by using perpendicular polarization (two beam case), by using a different pilot code for each beam in a CDMA system in addition to the CDMA spread spectrum code that is common to all beams, by using a different spread spectrum code for each beam in a CDMA system without pilot codes, by using a different training sequence (e.g., pilot code) multiplexed into each beam in a TDMA system. Persons skilled in the art will appreciate that there are other orthogonal beam techniques not listed above or techniques that use different combinations of the above techniques that are equivalent for providing a means for the receiver at the remote station to separately identify the individual beams and recover the signals they carry.

Please replace the paragraph beginning at page 9, line 17, with the following rewritten paragraph:

There are several means to implement controlled directional antennas. In FIG. 6, known hex controlled directional antenna system ~~6~~600 includes six co-sited corner reflector antennas, such as corner reflector antenna 608, arranged in a circle and all depicted in plan view. Each corner reflector antenna 608 includes a single half wave dipole 612 as an exciter element and corner reflectors 614. Each corner reflector antenna 608 illuminates a 60 degree beam width in plan view. Hex diversity antenna system 600 has been shown to provide angle location information that gives the bearing angle from a base station to the remote station based on received signal strength at 820 MHz (Rhee, Sang-Bin, "Vehicle Location In Angular Sectors Based On Signal Strength", IEEE Trans. Veh. Technol., vol. VT-27, pp 244-258, Nov. 1978). Such co-sited corner reflector antennas could divide a 360 degree coverage into three sectors (120 degree antennas), four sectors (90 degree antennas), five sectors (72 degree antennas), eight sectors (45 degree antennas), or any convenient number of sectors that may be realizable.

Please replace the paragraphs beginning at page 10, line 16, with the following rewritten paragraphs:

In FIG. 7, known ~~stearable~~ steerable beam phased array antenna 720 includes an array of exciter elements 722 (e.g., half wave dipole) disposed to be spaced from ground plane or reflector plane 724. FIG. 7 depicts eight radiating elements, but more or fewer elements may be used. Each exciter element 722 is fed with a signal from a corresponding phase shifter 726. Each phase shifter 726 alters the phase and attenuates (or amplifies) the amplitude of signal S according to a corresponding individual control portion of control signal C. For example, control signal C includes 8 phase shift parameters and 8 attenuation parameters. Each phase and amplitude parameter individually controls the phase and amplitude radiated from a corresponding element of the eight exciter elements of antenna 720. The angular beam width of such an antenna is limited by the ratio of the wavelength of the signal being radiated divided by the aperture dimension D; however, by controlling signal amplitudes on exciter elements 722 as distributed across the antenna with what is called a weighting function, the beam may be shaped to broaden the beam, flatten the center of the beam and/or suppress side lobes. By controlling the gradient of the phase at the exciter elements across the antenna, the beam may be electronically directed to point in a controlled direction.

In a variant of the second and third embodiments, the antenna system for transmitter 1 (FIG. 1) includes plural phased array antennas 720 organized in a multi-antenna system. In FIG. 8, an exemplary multi-antenna system may include three antennas (taken to be phased array antennas 720) arranged to point outward in equally spaced angular direction so that the three phased array antennas 720 are formed into the antenna system at the base station. Each antenna 720 is designed to cover a 120 degree sector. The base station locates the remote station by electronically scanning antenna 720. Amplitude weights for each radiating element are preferably set to a maximum and are all equal so that the antenna provides its narrowest beam (most directional beam). The receive beam is scanned in steps by first computing the phase parameters for control signal C that represent a gradient in phase across the antenna to achieve a desired beam point, and then controlling antenna 720 to point in the desired direction. Second, a receiver at transmitter 1 (FIG. 1) detects any received signal strength. The steps of pointing a receive beam and detecting a signal strength are repeated at each of several beam positions until the entire sector covered by antenna 720 has been scanned. In this way, the angle location of

remote station 2 is determined to a precision limited only by the narrowest achievable beam width of antenna 720. Once the location of direct path 3 and indirect path 5 are determined to be in different sectors (e.g., 120 degree sectors), antennas 106 and 108 (FIG. 5) are selected from the plural antennas 720 of the antenna system that are closest to direct path 3 and indirect path 5, and within the sector covered by each selected antenna 720, the phase gradients that define beams pointing at the angle locations for direct path 3 and for indirect path 5 are determined. Alternatively, when paths 3 and 5 lie in a single sector, two transmitting beams can be formed within the single sector to be directed along paths 3 and 5 if the antenna system is capable of forming the two beams in the single sector (see discussion below with respect to FIG. 10).

In FIG. 9, antenna system 930 includes four radiating elements 932 disposed to be spaced from ground plane or reflector plane 934. Each radiation or exciter element 932 is fed with a signal from known Butler matrix 936. The Butler matrix provides phase shifting and combination functions that operate on signals S1, S2, S3 and S4 so that the radiation from the four exciter elements 932 combine to generate four fixed angularly directed and orthogonal beams B1, B2, B3 and B4. In general, a Butler matrix performs a Fourier processing function to feed M radiating elements so as to form M fixed and orthogonal beams ("angular bins"). For example, -in antenna system 930, signal S1 is transmitted only in first beam B1, signal S2 is transmitted only in second beam B2, signal S3 is transmitted only in third beam ~~B4~~B3, and signal S4 is transmitted only in fourth beam B4. A switching matrix may be used to direct desired signals (e.g., the signals CH1 and CH2 of FIG. 5) onto any of the lines for signals S1, S2, S3, and S4 and from there into respective beams B1, B2, B3 and B4.

In a variant of the second and third embodiments, the antenna system for transmitter 1 (FIG. 1) includes plural "Butler matrix" antennas 930 organized in a multi-antenna system. In FIG. 8, an exemplary multi-antenna system includes three antennas (taken here to be "Butler matrix" antennas 930) arranged to point outward in equally spaced angular direction so that the three "Butler matrix" antennas 930 are formed into the antenna system at the base station. Each antenna 930 is designed to cover a 120 degree sector with, for example, four beams. The base station locates the remote station by electronically switching between the four beams (each 30 degrees) of each of the three antennas 930 and detecting the signal strength received. In this

way, the angle location of remote station 2 is determined to a precision of one beam width of antenna 930. Once the locations of direct path 3 and indirect path 5 are determined, antennas 106 and 108 (FIG. 5) are selected from the two different "Butler matrix" antennas 930 that make up the antenna system for transmitter 1 (FIG. 1) if direct path 3 and indirect path 5 lie in different sectors. The two particular "Butler matrix" antennas 930 are selected to cover the sectors that are closest to direct path 3 and indirect path 5, and from there, a particular beam within each selected antenna 930 is selected that most closely aligns with the path. Alternatively, antennas 106 and 108 may be selected to be different beams of the same "Butler matrix" antenna 930. Within the sector covered by each antenna 930, the beam pointing at the angle location for each of direct path 3 and indirect path 5 is selected by a switch matrix (not shown).

In FIG. 10, antenna 40 is a modified version of phased array antenna 720 to provide two independently steerable and shapable beams. Antenna 40 includes an array of exciter elements 42 (e.g., half wave dipole) disposed to be spaced from ground plane or reflector plane 44. FIG. 10 depicts eight radiating elements, but more or fewer elements may be used. However, unlike antenna 720, each exciter element in antenna 40 is fed by a signal from a corresponding summer 48. Each summer 48 superimposes (e.g., adds) signals from two corresponding phase shifters 46-1 and 46-2. All phase shifters 46-1 form a first bank of phase shifters, and all phase shifters 46-2 form a second bank of phase shifters. Each phase shifter 46-1 in the first bank alters the phase and attenuates (or amplifies) the amplitude of signal S1 according to a corresponding individual control portion of control signal C1. For example, control signal C1 includes 8 phase shift parameters and 8 attenuation parameters to individually control the phase and amplitude output from the corresponding phase shifter 46-1. Correspondingly, each phase shifter 46-2 in the second bank alters the phase and attenuates (or amplifies) the amplitude of signal S2 according to a corresponding individual control portion of control signal C2. For example, control signal C2 includes 8 phase shift parameters and 8 attenuation parameters to individually control the phase and amplitude output from the corresponding phase shifter 46-2. Summers 48 combine the outputs of respective phase shifters 46-1 and 46-2 and provide the combined signal to radiating elements 42. In this way, control signal C1 controls a first beam that radiates signal S1, and control signal C2 simultaneously controls a second beam that radiates signal S2.

In a variant of the second and third embodiments, the antenna system for transmitter 1 (FIG. 1) includes plural phased array antennas 40 organized in a multi-antenna system. In FIG. 8, an exemplary multi-antenna system includes three antennas (taken here to be phased array antennas 40) arranged to point outward in equally spaced angular direction so that the three phased array antennas 40 are formed into the antenna system at the base station. Each antenna 40 is designed to cover a 120 degree sector with two independently shapable and steerable beams. The base station locates the remote station by electronically scanning a beam of antenna 40 as discussed above with respect to antenna 720 (FIG. 7). Once the location of direct path 3 and indirect path 5 are determined, antennas 106 and 108 (FIG. 5) are selected from the plural antennas 40 of the antenna system that are closest to direct path 3 and indirect path 5, and within the sector covered by each selected antenna 40, the phase gradients that define beams pointing at the angle location for direct path 3 and for indirect path 5 are determined.

Please replace the paragraphs beginning at page 14, line 6, with the following rewritten paragraphs:

In a fourth embodiment, the base station uses a time division multiple access (TDMA) transmitter instead of a spread spectrum CDMA transmitter. In FIG. 12, training sequence TS1 is modulated in QPSK modulator 101 and from there fed to a first input of multiplexer 105, and training sequence TS2 is modulated in QPSK modulator 103 and from there fed to a first input of multiplexer 107. Training sequences TS1 and TS2 are orthogonal and provide the means by which remote station 2 can discern between the beams in much the same ~~was~~ way as pilot codes help distinguish beams in a CDMA system. In the TDMA system, multipliers 12 and 14 (of FIGS. 4, 5 and 11) are omitted and channel signals CH1 and CH2 are fed to second inputs to multiplexers 105 and 107, respectively. In this fourth embodiment, amplifiers 102 and 104 independently amplify or attenuate the outputs of respective multiplexers 105 and 107. The outputs of amplifiers 102 and 104 are fed to the antenna system (through up converters, etc., not shown). The antenna system may provide the overlaid coverage of diversity antennas 16, 18 (FIG. 4) as in the first embodiment or may provide controlled directional coverage of directional antennas 106, 108 (FIGS. 5 and 11) as in the second and third embodiments. Moreover, in the

case of controlled directional coverage, a variant may be to forego power management and omit amplifiers 102, 104 and rely on angle (beam) diversity by steering beams from directional antennas 106, 108. A data slot in a time division system may include, for example, 58 data bits, followed by 26 bits of a training sequence, followed by 58 data bits, as in a GSM system. The training sequence identifies the source of signal S_{IN} and the individual beam to remote station 2 so that the remote station can separately discern the beams. In this way, remote station 2 can separately receive the two beams using the training sequences, instead of using orthogonal spreading codes OC as in a CDMA system.

Although two beams are discussed, extensions to higher order coding techniques with more beams are straightforward,~~.~~ ~~For~~ for example, four symbols (S_1, S_2, S_3, S_4) encoded into four channel signals (CH1, CH2, CH3, CH4) in four symbol time slots so that the original symbols are recoverable from the encoded channel signals. The four channel signals are then transmitted from the base station in four beams, each beam corresponding to a channel signal of the channel signals CH1, CH2, CH3, and CH4. Although QPSK modulation techniques are discussed herein, extensions to other PSK modulation techniques are straightforward, and extensions to other modulation techniques (e.g., QAM) are equally useable.

In FIG. 13, a closed loop control system to manage transmit powers is depicted as process S10. In step S102, the base station selects the power level to be transmitted from each antenna. For example, in a two antenna system, the base station selects powers P1 and P2 based on the total power (i.e., P1 + P2) as defined by a conventional power control loop (e.g., a control loop typical to a CDMA system) and the relative powers (i.e., P1/P2) as defined by power control coefficients measured at remote station 2. In step S104, a value representing the selected transmit power level is sent to the remote station in a signaling channel. In step S106, the power level received at the remote station from each antenna radiation pattern is measured, and corresponding power control coefficients are determined. The power control coefficients for each antenna radiation pattern are determined at remote station 2 to be proportional to the received power at remote station 2 divided by the transmitted power as indicated by the power level value that is sent to the remote station in a signaling channel. In step 106 the power control coefficients are sent from the remote station to the base station in a signaling channel. In step

S108, the power control coefficients from step S106 are compared for each antenna. In step S110, adjustments in transmit signal power are determined according to the comparison ~~comparision~~ of step S108. The adjustments are made to increase transmit powers sent in channels that have favorable transmission qualities and reduce transmit powers in channels that have poor transmission qualities. Then, in step S102 at the ~~begining~~ beginning of the cycle, the base station selects adjusted transmit powers to form the basis for the powers to be transmitted from the antennas during the next cycle of the closed loop beam power management. The loop cycle delay may be one time slot as in a third generation TDMA system.

Alternatively, the remote station may compare (in step S108) the power control coefficients for each antenna from step S106 and then compute power coefficient indicator information to be sent from the remote station to the base station in an up link signaling channel. For example, a ratio of the power control coefficients (e.g., P1/P2 in a two antenna case) may be advantageously computed as the power coefficient indicator information and transmitted in the up link direction. Or the power coefficient indicator information may be the quantized value of the ratio (e.g., a single bit indicating whether P1 > P2 or not).

Please replace the paragraphs beginning at page 17, line 9 with the following rewritten paragraphs:

Antenna system 216 is capable of generating plural beams (i.e., a multi-beam antenna) and the base station includes antenna control 218 to control the multi-beam antenna to form the plural beams. In one embodiment, the multi-beam antenna may be a multi-port Butler matrix antenna, and in this case, transmitter 214 will include amplifiers to scale the first and second space-time coded signals to form respective first and second scaled space-time coded signals based on the respective first and second adjusted transmit powers, and antenna control 218 will include a switch to couple the first and second scaled space-time coded signals into respective first and second input ports of the Butler matrix antenna to form the respective first and second beams.

Alternatively, the multi-beam antenna includes a phased array antenna system, and antenna control 218 includes a beam steering controller to ~~-~~form first and second weighting

functions. The beam steering controller includes logic to input the first and second weighting functions into the phased array antenna system to scale antenna gains of the respective first and second beams based on the respective first and second adjusted transmit powers without scaling amplifiers in transmitter 214. The phased array antenna system may include either a plural beam phased array antenna (e.g., 40 of FIG. 10) or plurality of phased array antennas (e.g., 720 of FIG. 7).

Please replace the paragraph beginning at page 18, line 4, with the following rewritten paragraph:

Remote station 230 includes remote station receiver 234, detector 236, power measurement circuit 238 and processor 240. Receiver 234, detector 236, power measurement circuit 238 and processor 240 constitute a circuit by which remote station 230 can determine an indicated path attenuation characteristic based on a power received from the first radiation pattern and measured in circuit 238 and an initial transmit power determined in detector 236. With this circuit, remote station 230 can determine an indicated first path attenuation characteristic for a first radiation pattern of antenna system 216 and an indicated second path attenuation characteristic for a second radiation pattern of system 216 since the two radiation patterns are separately receivable. Detector 236 determines the initial transmit power, power measurement circuit 238 measures the power received from the radiation pattern as received by receiver 234, and processor 240 determines a power control coefficient to be proportional to the power received divided by the value of the initial transmit power. Power measurement circuit 238 measures an instantaneous power received, or in an alternative embodiment, measures an averaged power received, or in an alternative embodiment measures both and forms a combination of the instantaneous power received and the average power received. Remote station 230 further includes transmitter 242 to send values of the power coefficient indicator information or of the indicated first and second path attenuation characteristics to the base station.

Please replace the paragraph beginning at page 20, line 9, with the following rewritten paragraph:

In either variant, the power allowed to be transmitted from an antenna will be greater for antennas associated with paths determined to ~~posses~~ possess a lesser path attenuation. For example, an indicated path attenuation characteristic is advantageously determined to be the ratio of the power received at remote station 2 to the power transmitted from base station 1. In this way, little or no power is transmitted in a path that is not well received by remote station 2, while a greater power is transmitted in a path that is well received by remote station 2. In many multi-path environments, increasing power transmitted in a path that has too much attenuation does little to improve reception at remote station 2, but such increased power would contribute to co-channel interference experienced by other remote stations. To improve the overall cellular radio system, the paths with the least attenuation are permitted the greatest transmit beam powers. The base station adjusts the power transmitted from each antenna by control scaling signals SA1 and SA2 (FIGS. 4 and 5) or by controlling the overall antenna gain for each beam by adjusting the amplitude parameters in control signal C (of FIG. 6) or in signals C1 and C2 (of FIG. 9).

Please replace the paragraph beginning at page 22, line 22, with the following rewritten paragraph:

The circuit to measure the angular power spectrum includes receiver 220 (FIG. 14) and such signal and data processing circuitry as is required to determine the angular power spectrum and peaks therein as discussed below. When a peak in the angular power spectrum is detected, an angular position is defined by the peak. Then, to direct the beam direction toward an angular position as detected, antenna controller 218 ~~computer~~ computes an array steering vector to input into antenna system 216 (FIG. 14). When an excessive number of peaks are detected in the angular power spectrum, power management controller 222 (FIG. 14) selects the angular directions to be used to form beams. Power management controller 222 may select beams directions toward specific angle of arrival paths (i.e., peaks), or power management controller 222 may select beams directions, and possibly beam widths, so as to cover a detected angular

spread. The selected directions are provided to antenna controller 218 to form the beam commands to the antenna system.

Please replace the paragraph beginning at page 24, line 1, with the following rewritten paragraph:

An antenna system based on a phased array antenna provides an opportunity to generate a more interpolated angular power spectrum (e.g., G1 of FIG. 18) by steering the antenna beam to point at as many angular positions as desired to generate the angular power spectrum. Power management controller 222 (FIG. 14) generates the angular power spectrum in process S20 (FIG. 15) by looping on θ in steps S20A and S20B and determining the angular power in step S21. Given the angle θ, power management controller causes antenna controller 218 (FIG. 14) to ~~computer~~ compute an array steering vector and point the antenna (step S211 of FIG. 16). The phased array antenna then receives a signal in receiver 220 (FIG. 14) from remote station 2 in each radiating element of the phased array antenna to form a signal vector in step S212 of FIG. 16. Each radiating element is preferably spaced apart from an adjacent element by one-half of the wavelength. For example, if a phased array antenna were to include 12 radiating elements (only 8 radiating elements are shown in antenna 720 of FIG. 7), the signal received in each of the 12 radiating elements would be sampled to form a measured signal vector. The sampled signal is preferably a complex value having amplitude and phase information. The signals from each of the 12 radiating elements are formed into a 12 element received signal vector as column vector $\hat{x}$. Next, the complex conjugate transpose of received signal vector $\hat{x}$ is formed as row vector $\hat{x}^H$, and the spatial covariance matrix of the received signal, $R = \hat{x}\hat{x}^H$, is calculated in step S213 (FIG. 16). When received signal vector $\hat{x}$ is 12 elements long, then the spatial covariance matrix of the received signal, $R = \hat{x}\hat{x}^H$, will be a 12 by 12 matrix.

Please replace the paragraph beginning at page 30, line 7, with the following rewritten paragraph:

The present invention fits well in a base station where the antenna system employs digital beam forming techniques in a phase array antenna (e.g., antenna 720 of FIG. 7 and antenna 40 of

FIG. 10). With digital beam forming techniques, the apparent number elements in an antenna array (i.e., the apparent aperture dimension) can be electronically adjusted by using zero weighting in some of the elements according to the available angular spread. In this fashion, the beam width can be easily adapted by the base station to match the angular spread. This beam width control operates as an open loop control system.

Please replace the paragraph beginning at page 32, line 5, with the following rewritten paragraph:

In a preferred variant, one antenna is used as a reference with its corresponding weight set to 1+j0 (or amplitude = 1, phase = 0^{o}). The other weight is determined relative to the reference weight. In general, base station 210 may employ two or more channels, each with an antenna, diplexer, weighting amplifier and all associated encoders. If M is the number of transmitting antennas, then the number of weights that must be determined is M - 1 since only differential information (i.e., weights) need to be determined. Without loss of generality, the following description ~~focusses~~ focuses on two transmitting antennas (M = 2) so that only one complex number weight need be determined.

Please replace the paragraphs beginning at page 33, line 3, with the following rewritten paragraphs:

Processor 240 determines the channel state information from the normalized ratio or ratios. Each ratio includes both amplitude and angle information. It is the object of this process to adjust the phase of the signal transmitted from the two antennas (or more) so that they will constructively reinforce at remote station 230. To ensure constructive reinforcement, it is desired to phase delay or advance a signal transmitted from each antenna relative to the reference antenna. For example, if first antenna 16 is the reference antenna, then the angle portion of the ratio for the signal received from second antenna 18 is further examined. If this angle is advanced 45 degrees relative to the reference antenna, it will be necessary to introduce a 45 degree delay at the transmitter for second antenna 18 to achieve constructive reinforcement at remote station 230. Thus, processor 240 determines the amount of phase delay or advance

needed to achieve constructive reinforcement at remote station 230 by adding the desired additional delay to the phase of the initial transmitted signal, and if the addition result is greater than 360, then subtracting 360. This phase angle then becomes the phase angle transmitted as part of the channel state information.

Processor 240 also determines the amplitude part of the channel state information. The object here is to ~~emphasis~~ emphasize the antenna with the best path (i.e., lowest attenuation path) from the antenna to remote station 230. The total power transmitted from all antennas may be regarded here as constant. The question to be resolved by the amplitude part of the channel state information is how to divide up the total transmitted power.

Please replace the paragraph beginning at page 34, line 16, with the following rewritten paragraph:

If two bits were reserved in the up link signaling channel for amplitude feedback information, the bits could define four amplitude states. For example, processor 240 would compute a ratio between the path attenuation from antenna 16 and the path attenuation from antenna 18 and then slice the ratio according a predetermined range of values that this ratio can take. The slicing process defines four sub-ranges and identifies into which of the four ranges the computed ratio fits. Each sub-range would define the desired split of the total power transmitted by two antennas 16 and antenna 18 to be, for example, 85%/15%, 60%/40%, 40%/60% and 15%/85%, respectively. The two bits would thus encode one of these splits as the desired split in the total power transmitted by two antennas.

Please replace the paragraph beginning at page 34, line 29, with the following rewritten paragraph:

The channel state information to be transmitted is a complex coefficient in the form of phase and amplitude information, and it is to be transmitted from remote station 230 to base station 210 in a number of segments (N segments) carried in corresponding slots in an up link signaling channel. A partition of the N slots into N1 and N2 (where N = N1 + N2) is done in such a way that the first N1 slots carry phase information and the remaining N2 slots carry

amplitude information. In principle N1 and N2 can be arbitrarily chosen, but a common value for these parameters could be N1 = N2 = N/2. Assume that each slot reserves K bits for carrying the corresponding information segment. The ~~the~~ phase can be resolved to an accuracy of:

$$\Phi_{\min} = \frac{360}{2^{N_1 K}},$$

and the amplitude can be resolved to an accuracy of:

$$A_{\min} = \frac{A_{\max}}{2^{N_2 K}},$$

where A_{max} is the maximum amplitude.

Please replace the paragraphs beginning at page 39, line 1, with the following rewritten paragraphs:

In FIG. 20, a method practiced on processor 240 includes several steps that are typically implemented in the processor with software modules and/or logic. However, persons skilled in the art will appreciate that the steps may be implemented in the processor using ASIC or other custom circuitry.

In step S2002, for each of the plural antennas, the processor receives the received signal strength and phase (a complex number) as determined by signal measurement circuit 238. In step S2004, the processor selects one of the received signals to be a reference signal. This selection may be arbitrary or it may be to select the signal with the greatest phase lag (least likely to need to or want to be slowed down). In step S2006, the processor divides the received signal strength and phase (a complex number) determined by signal measurement circuit 238 by the received reference signal strength and phase (a complex number). The ratio for the reference antenna is, by definition, 1+j0. In the case of two antennas, there is only one ratio to be determined and sent, the ratio of the reference antenna being a constant reference.

In step S2008 (FIG. 20), processor 240 determines the amount of phase delay or advance needed at each transmitting antenna to achieve constructive reinforcement at remote station 230. If the reference signal is chosen to be the signal with the most lag, the remaining signals may achieve phase alignment with the reference signal by adding a delay at the antenna. Step S2008 determines the required additional delay, but if the additional phase delay added to the phase of

the non-reference signal results in a phase that is greater than 360 degrees, then subtract 360. This phase angle then becomes the phase angle transmitted as part of the channel state information. Persons skilled in the art in light of these teachings will appreciate that step S2008 may be performed in the base station so that only the phase angle of the channel impulse response need be sent in the up link signaling channel.

In step S2010, power management information to define the transmit distribution (the allocation of the total power among the transmit antennas) is determined. Persons skilled in the art will appreciate in light of these teachings, that the amplitude portion of the channel state information may be computed by various means. Described here is a table look up means, but other means to compute the split of the total power to be transmitted are equivalent.

For example, the relative amplitude and relative phase of the signal from each antenna may be transmitted in the up link signaling channel for the base station to further process. Alternatively, the remote station may determini~~in~~e in step S2010 an indicia of the desired power distribution. If only one bit were reserved in the up link signaling channel for amplitude feedback information, the bit would preferably command 80% of the total power to be transmitted by the antenna with the lowest attenuation path to remote station 230 and command 20% of the total power to be transmitted by the antenna with the highest attenuation path. If two bits were reserved in the up link signaling channel for amplitude feedback information, the bits could define four amplitude sub-ranges. For example, 85%/15%, 60%/40%, 40%/60% and 15%/85%, respectively. The two bits would thus encode one of these sub-ranges as the desired split in the total power transmitted by two antennas. Extensions to more antennas or to the use of more bits to represent the amplitude portion of the channel state information will be apparent to persons of ordinary skill in the art. The exact nature of the table look up or other means depends on the number of bits reserved in the up link format to carry the amplitude portion of the channel state information.

In step S2012, the channel state information is segmented and packed into the formats described herein (e.g., Table 1). In step S2014, the segments are sequentially transmitted in the up link signaling channel to the base station. From there, the respective weights for the antennas are recovered and applied to amplifiers 102 and 104 (FIG. 19).

Please replace the paragraph beginning at page 42, line 20, with the following rewritten paragraph:

The direct signal from beam D5 is received at remote station 2 before the indirect signal from beam D2 is received by a time τ as depicted in FIGS 24 and 25. In order to maintain the best orthogonality between the signature codes, it is desirable to align the signals in time. A receiver (possibly at the base station and possibly at remote station 2 as discussed below) determines the time delay τ necessary to align the signals. The last signal received at remote station 2 (e.g., signal I2) may be regarded as a reference space-time coded signal. The remaining signals may then be regarded as at least one remaining space-time coded signal (e.g., signal I5). In this embodiment, ~~the~~ at least one remaining space-time coded signal is delayed in the programmable delay line of the base station (see FIG. 26) before being transmitted. The signal or signals is or are delayed by a sufficient delay to ensure that each of the at least one remaining space-time coded signal will align in time with the reference signal when received at the remote station. In the example depicted in FIG. 23, the last signal received at remote station 2 is signal I2 due to the extended length of multi-path 5. Signal I5 will need to be delayed so that it will arrive~~d~~ at remote station 2 at the same time that signal I2 arrives at remote station 2.

Please replace the paragraph beginning at page 45, line 6, with the following rewritten paragraph:

The base station encodes each signal of the at least two space-time coded signals with a signature code that is mutually orthogonal to each other signature code encoded in the at least two space-time coded signals so as to form a reference space-time coded signal and at least one remaining space-time coded signal (see 12 and 14 of FIG. 26). In the example of FIG. 23, the reference space-time coded signal may be regarded as signal I2 and the at least one remaining space-time coded signal may be regarded as signal I5. However, persons skilled in the art will appreciate in light of these teachings how to extend the present embodiment to more than two space-time coded signals.

Please replace the paragraph beginning at page 45, line 26, with the following rewritten paragraph:

However, in frequency division duplex (FDD) systems, a feedback measurement could provide~~d~~ improved results at the cost of additional complexity. In frequency division duplexed systems where up link and down link communications are carried out over different frequencies, it is not possible to exactly determine the down link channel state from up link information since the two directions are based on different frequencies.

Please replace the paragraphs beginning at page 46, line 26, with the following rewritten paragraphs:

In FIG. 28, set up process S2800 measures the up link channel response and sets the measured delays to control the down link channel transmission. Process S2800 includes step S2802 to measure the channel response, step S2804 to select beams to use, step S2806 to determine time delays for the selected beams, and step S2808 to configure variable delay lines in the base station (see FIG. 26) to impose the determined delays. The variable delay lines may be constructed from a sequence of fixed delay elements with multiple taps disposed between the elements. The delay line is varied by selecting different taps as an output using a switch. In step S2804, the base station selects at least two beams of plural beams formed by a multi-beam antenna array associated with a base station (although only two beams are shown in FIGS. 23 and 26). In the beams are transmitted corresponding at least two space-time coded signals produced by a space-time encoder (although only two signals are shown in FIGS. 23 and 26). The at least two beams include a reference beam and at least one remaining beam. In step S2806, the base station determines a time delay corresponding to each beam of the at least one remaining beam. In step S2808, the base station sets into a variable delay line the time delay corresponding to each beam of the at least one remaining beam. Each variable delay line is coupled between the multi-beam antenna array and the space-time encoder (see FIG. 26).

In FIG. 29, time align process S2920 marks the space-time coded signal for each selected beam with a signature code orthogonal to all other beams in step S2922, delays selected beams according to determined delay spreads in step S2924 and transmits the delayed signals to the

base station in step S2926. In step S2922, the base station encodes each signal of the at least two space-time coded signals with a signature code that is mutually orthogonal to each other signature code encoded in the at least two space-time coded signals so as to form a reference space-time coded signal and at least one remaining space-time coded signal. In step S2924, the base station delays each signal of the at least one remaining space-time coded signal in a respective variable delay line to form at least one delayed space-time coded signal. In step S2926, the base station transmits the reference space-time coded signal and the at least one delayed space-time coded signal in respective beams of the at least two beams.

In FIG. 30, a remote station using feedback process S2940 measures down link complex channel state information and feeds this information back to the base station. Process S2940 includes step S2942 to receive at least two identifier signatures (e.g., different pilot signals) from an antenna system associated with a base station, step S2944 to determine complex channel state information based on the received signals, step S2946 to segment the complex channel state information into a plurality of channel state information segments, and step S2948 to send the plurality of channel state information segments in a sequence to the base station. The sequence of segments sends the most significant bits of the phase angle before the least significant bits of the phase angle. The sequence of segments sends the most significant bits of the amplitude before the least significant bits of the amplitude. The sequence of segments sends a bit of the phase angle before a corresponding bit of amplitude having the same level of bit significance. It is noted that for feedback of the channel impulse response measurements, each beam (or antenna) should be associated with a unique pilot signature that is orthogonal to all other pilot signatures.